



# **Can an Automated Aquatic Biomonitoring System Identify Modes of Toxic Action and Detect Neurotoxicants?**

# Mobile Facilities





## **Briefing Objectives**

- **Automated biomonitoring overview**
- **USACEHR biomonitors in the field**
- **Possible future improvements**
  - **Evaluate modes of toxic action**
  - **Improve response to neurotoxics**



## **Automated Biomonitoring System Elements**

- Uses electronic sensors to monitor physiological responses (*whole organism emphasis*)
- Provides continuous, real-time monitoring in an automated system (*aquatic emphasis*)
- Provides an alarm when abnormal conditions are detected



## **Automated Biomonitor Responses**

<u><b>Type of Organism</b></u>	<u><b>Example Response</b></u>
<b>Algae</b>	<b>Fluorescence</b>
<b>Bacteria</b>	<b>Respiration</b>
<b>Zooplankton</b>	<b>Activity</b>
<b>Mussels</b>	<b>Valve movement</b>
<b>Aquatic Insects</b>	<b>Activity</b>
<b>Bees</b>	<b>Activity</b>



## **Automated Biomonitor Responses**

<u><b>Type of Organism</b></u>	<u><b>Example Response</b></u>
<b>Fish</b>	<b>Electric organ discharge</b>
	<b>Movement/activity</b>
	<b>Rheotaxis</b>
	<b>Ventilatory patterns</b>

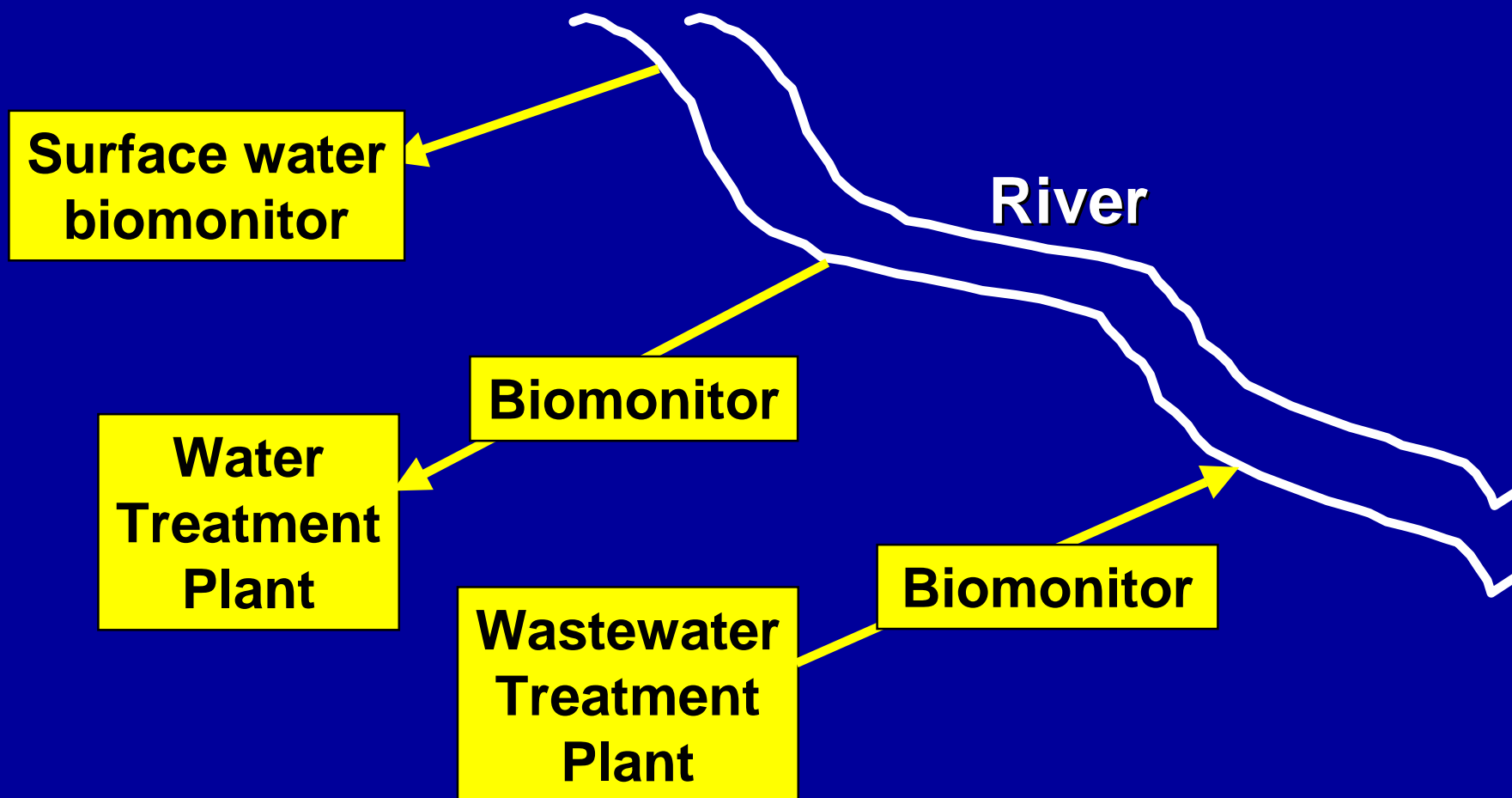


## **Biomonitor Advantages**

- **Provide early warning of developing toxic conditions**
- **Provide real-time, continuous data (remote option)**
- **Identify toxicity from unsuspected chemicals**
- **Integrate effects of multiple chemicals**
- **Provide biologically-directed water sampling**
- **Increase engineer/operator awareness of toxicity**



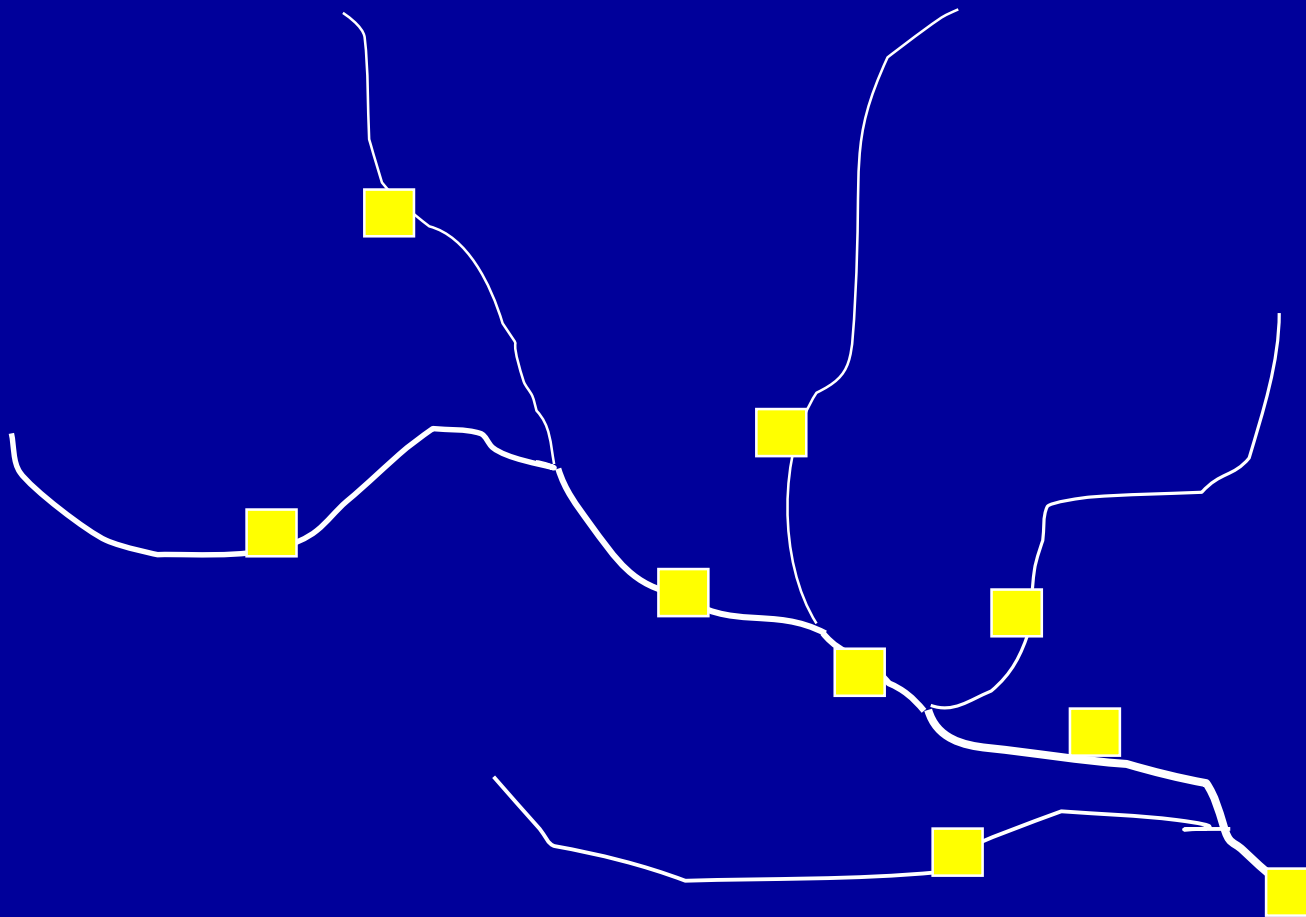
# **Automated Biomonitor Applications**







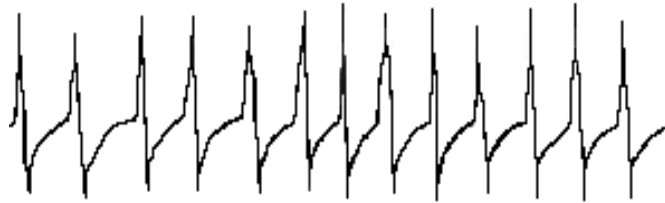
# Watershed Network



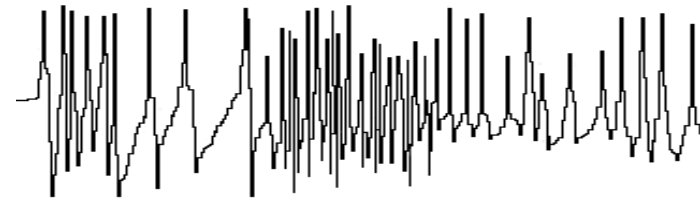


## **USACEHR Applications**

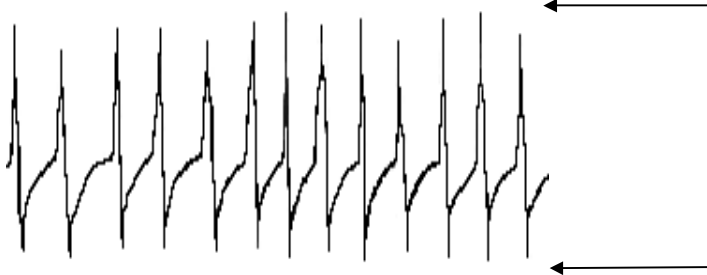
- **Aberdeen Proving Ground - effluent monitoring**
- **Chesapeake Bay - surface water monitoring**



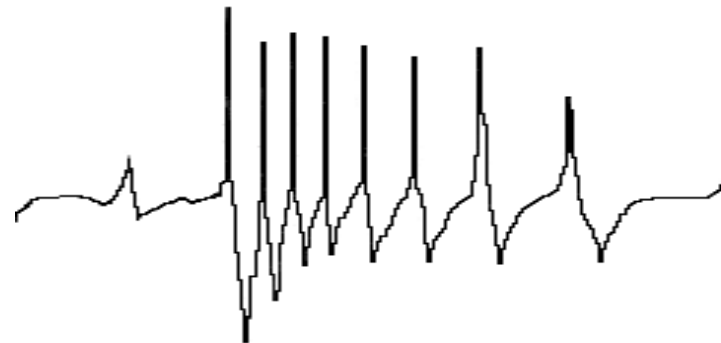
Ventilatory Frequency



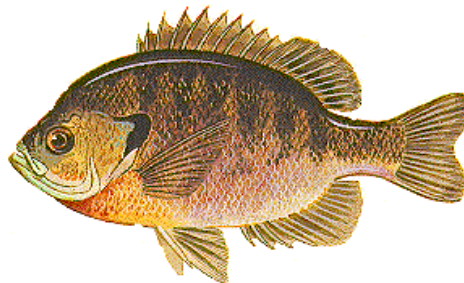
Whole Body Movement



Ventilatory Depth



Cough Frequency



## Bluegill Ventilatory Patterns



## **USACEHR Automated Biomonitoring: Future Emphasis**

- **Improve response to neurotoxicants**
- **Improve biomonitor data interpretation**



## **Improve Response to Neurotoxicants**

- **Background:**

- acoustic startle response is used as an indicator of sensory acuity in mammals
- in fish, startle response results from Mauthner cell stimulus → “C-start” escape
- fish in biomonitor show heightened startle response for some neurotoxicants (malathion, TMPP)



## **Improve Response to Neurotoxicants**

- **Issue**: Could incorporation of the “startle response” enhance biomonitor response to neurotoxicants?
- **Questions**
  - acoustic vs. visual stimulus?
  - detect enhanced vs. reduced responsiveness?
  - acclimation to repeated stimuli?
  - statistical analysis issues?



## **Improve Biomonitor Data Interpretation**

- **Background:**
  - **biomonitor provides non-specific response**
  - **laboratory studies have linked fish physiologic responses to general toxic mode of action**



## **Improve Biomonitor Data Interpretation**

- **Fish behavioral syndromes (Drummond and Russom, 1990)**
  - **behavioral responses of fish to acutely toxic levels of over 300 organic chemicals**
  - **three syndromes: hypoactivity, hyperactivity, physical deformity**
  - **parameters: locomotor activity, startle response, ventilatory activity, convulsions, vertebral deformities**





## **Improve Biomonitor Data Interpretation**

- **Fish acute toxicity syndromes (McKim and others, 1987-1990)**
  - **physiologic responses of trout**
  - **chemicals with varying modes of toxic action**
  - **PCA/DFA to classify 8 modes of action based on physiologic responses**
  - **nine physiologic variables classified 93% of fish (70/75)**



## **Fish Acute Toxicity Syndromes**

- **Example modes of action**
  - Narcosis
  - Polar narcosis
  - Acetylcholinesterase inhibitors
  - Respiratory uncouplers
  - Respiratory irritants
- **Physiologic parameters used in DFA analysis**
  - arterial pH, ventilation rate, cough rate, oxygen uptake efficiency, oxygen consumption (85%)
  - plus heart rate, hematocrit, arterial oxygen and carbon dioxide (93%)



## **Improve Biomonitor Data Interpretation**

- **Issue:** Can the physiological responses of fish, measured in a field biomonitor, be useful in assessing the toxic mode of action causing a biomonitor response?



## **Improve Biomonitor Data Interpretation**

- **Field Application Problems**
  - too few physiologic parameters, too many possible modes of action
  - response patterns not always from acute exposure
  - mixtures more likely than single chemicals
- **But ... may be a useful tool in conjunction with other lines of evidence (e.g., chemical analyses)?**